Effects of Compaction in the Subgrade of the Reinforced Sand Backfills with Geotextile on Bearing Capacity

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Results of the laboratory large scale model tests were carried out to determine the bearing capacity of shallow circular footing supported by reinforced sand with geotextile layers. The first tests of this study for optimizing the geometrical condition of geotextile in reinforced dry sand were performed. In these tests the optimized conditions of the number of reinforcement layers, critical depth of the first layer of reinforcement and the dimensions of the geotextile layer were determined. In the second tests sand subgrades were constructed in the optimized conditions under the reinforced sand backfills. Relative Density of Compaction of the sand subgrade in these tests was variable. This paper is an answer for this question that when we used of geotextile reinforcement in the backfills, increase in the Relative Density of Compaction in the subgrade have what effects on the bearing capacity. The bearing capacity in this study had been determined and compared with Plate Load Tests (ASTM-D1194).

Keywords: Geotextile, Reinforced Sand, Bearing capacity, Relative Density of Compaction, Subgrade

1. Introduction

Today, the using of the geotextiles as reinforcement in geotechnical applications is increasing. Use of the geotextile in the construction of the reinforced foundations to support the shallow footings, has considerable potential as a cost effective alternative conventional methods of support. In this method, the existing weak soil is removed up to a shallow depth and it is replaced by the soil reinforced whit one or more horizontal layers of high tensile strength geotextiles (Kumar and Saran 2002). Several researches shown the effects of the geotextiles on the ultimate bearing capacity (e.g., Yasrobi et. al., 2009; Gosh and Dey, 2008; Boushehrian and Hataf, 2003; Kumar and Saran 2002; Omar et. al., 1993; Binquet and Lee, 1975 and Giudo et. al., 1985).

When we use of the geotextile as reinforcement in the backfills, the specifications of the soil were changed. In the other hand, by using of geotextile in the soil, we can assume that we are crossed the new soil with different behavior. In this study we want to find when a

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foundation was constructed with geotextile, we must use a dense subgrade or can use of lower Relative Density of Compaction (Dr) in that.

2. Materials tested

A type of silica sand (161standard sand) patterned in Iran was used in this research. The grain size distribution curve of it is shown in Fig. 1 and its specifications are given in Table 1.

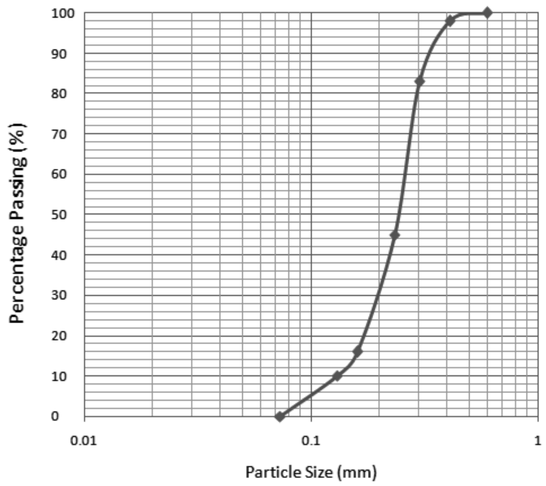

Fig. 1. Grain size distribution curve for sand

Table 1
Specifications of 161 standard sand

Parameter	Value
GS	2.66
Maximum void ratio (e max)	0.928
Minimum void ratio (e min)	0.583
D 50	0.26
F %	0
Coefficient of uniformity (Cu)	1.8
Coefficient of concavity (Cc)	1.19
K	0.0125

The nonwoven geotextile, it was used in this research was An Iranian nonwoven geotextile (namely, 2N400). The physical properties of this type of geotextile are given in Table 2.

Table 2
Physical properties of geotextile type 2N400

Fabric Properties	Test Method (ASTM)	Unit	
Polymer Type			PET
Unit Weight	D-5261	gr/m²	400
Thickness	D-5199	mm	1.60
Grab tensile strength	D-4632	N	1750
Grab elongation	D-4632	%	>50
Trapezoidal tear	D-4833	N	595
Puncture strength	D-4533	N	930

Wide with tensile	D-4595	kN/m	23.1

3. Laboratory model tests

The circular footing, it was made of stiff iron plate, had a diameter (*B*) of 200 mm. The bearing capacity tests were conducted in a square box with 100 cm × 100 cm × 80 cm (length × width × depth) dimensions. It is made of wooden panels supported by steal profiles. The inner side of the box was covered by a layer of plastic to reduce friction. It was filled with sand (161 standard sand). The model foundation was placed on the surface of sand bed. Fig. 2 shows a circular footing (diameter *B*) supported by sand, which is reinforced with *N* number of geotextile layers. The vertical space between geotextile layers is *h*. The top layer of geotextile is located at the depth *u*, measured from the bottom of the footing. The width and the length of the geotextile layers are *b*. The depth *d* of reinforcement below the bottom footing is calculated as:

$$d = u + (N - 1)\, h. \qquad [1]$$

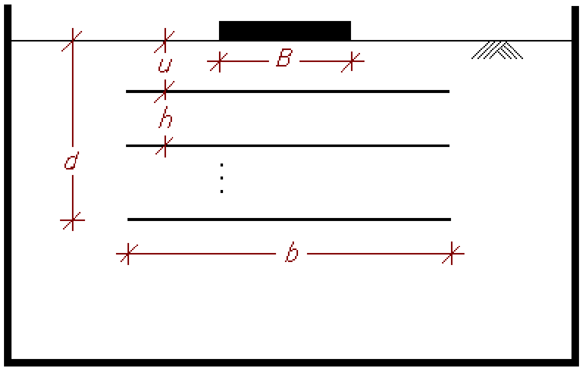

Fig. 2. The circular footing supported by sand reinforced with geotextile layers

In this we used of the results of Yasrobi et al. (2009) to optimize the dimensions of geotextile layers and also the critical depth of the first layer of reinforcement. Therefore *d*/*B*, *b*/*B* and *u*/*B* were selected 1, 3 and 0.25 respectively.

4. Testing program

In this research a group tests was planned. In these tests, the effects of Dr on the unreinforced sandy subgrades were investigated. The models in these tests were constructed in two sections. The first section was the unreinforced subgrade and the second section was the reinforced backfill. Dr in the reinforced backfill was considered as constant (35%), while in the unreinforced subgrade, as variable (35%, 45%, 55%, 65% and 75%).

5. Test procedure

For every loading test, the box was initially filled by pouring 100 mm thick layers of sand, among which reinforcement layers were placed. To obtain uniform compaction, each layer was

tamped by marshal hammer on the iron plate (30 cm × 30 cm). The range of variation for the Dr was ±5% of the average value.

6. Test results

The footing was loaded statically using dead weights and displacement was measured for each load. The load was applied to the model footing by a reaction frame through hydraulic jack. Settlement of the footing was read on three digital gauges mounted at the ends of the model footing and attached to the steel frame of the box with the help of three magnetic bases and three connecting rods. Then the curve of stress-settlement was plotted. The experimental ultimate bearing capacity in Plate Load Test (PLT) was determined at the allowable settlement of 2.51 cm (ASTM-D1194).

7. Effects of Dr in the subgrade

In this group of tests, the effects of Dr of unreinforced sandy subgrades were determined. The models in these tests were constructed in two sections. The bottom section was the unreinforced subgrade and the upper section was the reinforced backfill. Dr in the reinforced backfill was in constant the dense consistency term (Dr=35%) and in the unreinforced subgrade it was taken as variable from loose to dense consistency term (Dr=35%, 45%, 55%, 65% and 75%).

Two geotextile layers were selected as beneficial number of layers from the first series of tests for reinforcing (N=2). The effective depth of placement of the first layer of geotextile was spotted as 0.25B (u=5 cm). The maximum width of reinforcement required for mobilization of maximum bearing capacity was selected as 3B (=60 cm). Therefore, subgrade and reinforced backfills in these series had the depth of 65 cm and 15 cm, respectively.

Fig. 3 shows the results of PLT results on the circular footing supported by a constant reinforced backfill on the unreinforced subgrade with the variable Dr.

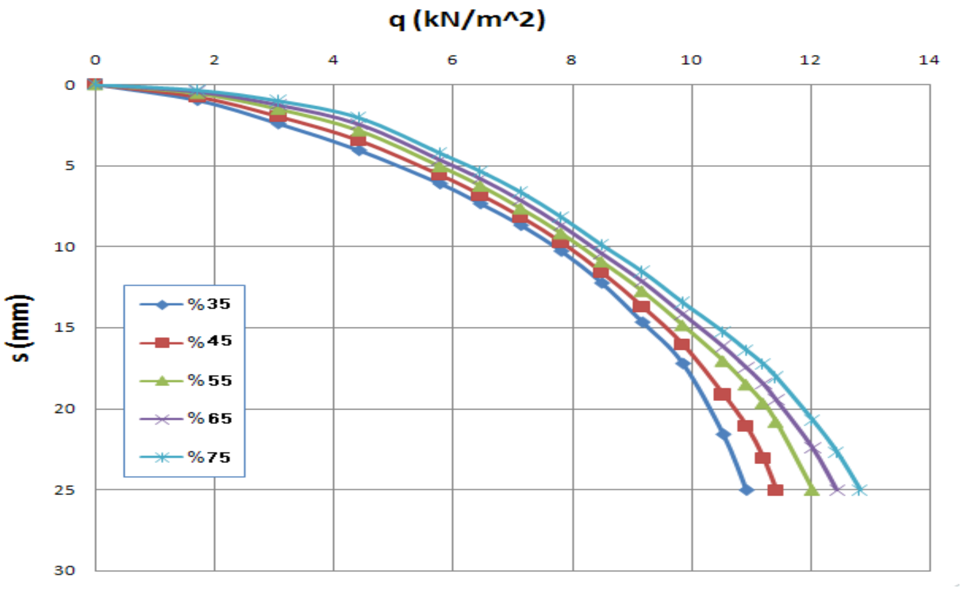

Fig. 3. The effect of variable Dr in the unreinforced subgrades on the bearing capacity

This figure clearly shows that the bearing capacity increase when the Dr increased. In the models shear failure is the local shear failure.

The increase in the bearing capacity was expressed by a non-dimensional parameter, Stress Ratio (QR) as:

QR = $q/q_{(75\%)}$ [2]

Where, q is the bearing capacity in the foundation with variable Dr in the subgrades and $q_{(75\%)}$ for the unreinforced sandy subgrade with 75% Dr. The $q/q_{(75\%)}$ obtained from these PLT results are plotted with the variation of Dr in Fig. 4.

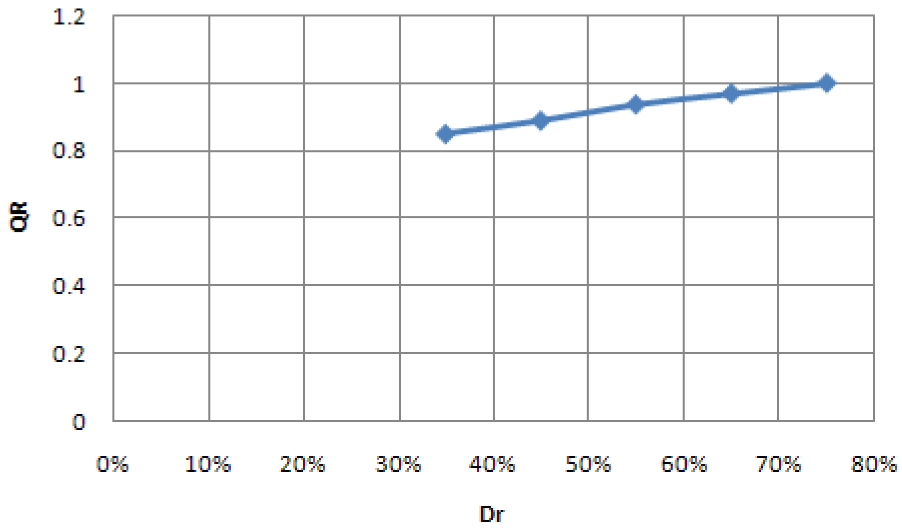

Fig. 4. The effect of the variation of Dr on $q/q_{(75\%)}$

The Stress Ratio (QR) for Dr of 35%, 45%, 55%, 65% and 75% were equal to 0.85, 0.89, 0.94, 0.97 and 1.0, respectively. These results mean that the rate of variation in QR decreases when the Dr increases.

The decrease in the settlement was expressed by a non-dimensional parameter Settlement Ratio (SR).

SR = $s/s_{(MAX)}$ [4]

In this evaluation, settlement (s) was match by q=10.91 kN/m^2. The maximum settlement ($s_{(MAX)}$) selected for this parameter was obtained from ASTM-D1194 (25.1 mm). Fig. 3 shows the plot of the variation of SR against Dr obtained by using the bearing capacity values from the Fig.3.

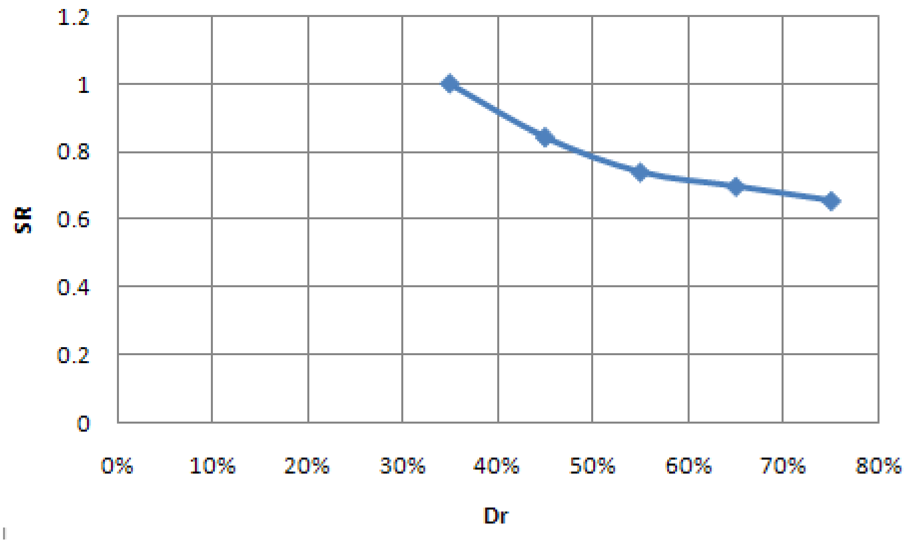

Fig. 5. The effect of the variation of Dr on $S/S_{(MAX)}$

SR for 35%, 45%, 55%, 65% and 75% were 1, 0.84, 0.74, 0.7 and 0.65, respectively. The rate of variation in SR decreases when the Dr increases.

When the plots of QR (Fig. 4) and SR (Fig. 5) were fitted, the optimum Dr was found. Figure 6 shows the QR and SR plots together. The optimum Dr that was found from Fig. 10 is 42%. It means that Dr=42% is the Dr for both the bearing capacity and the settlement.

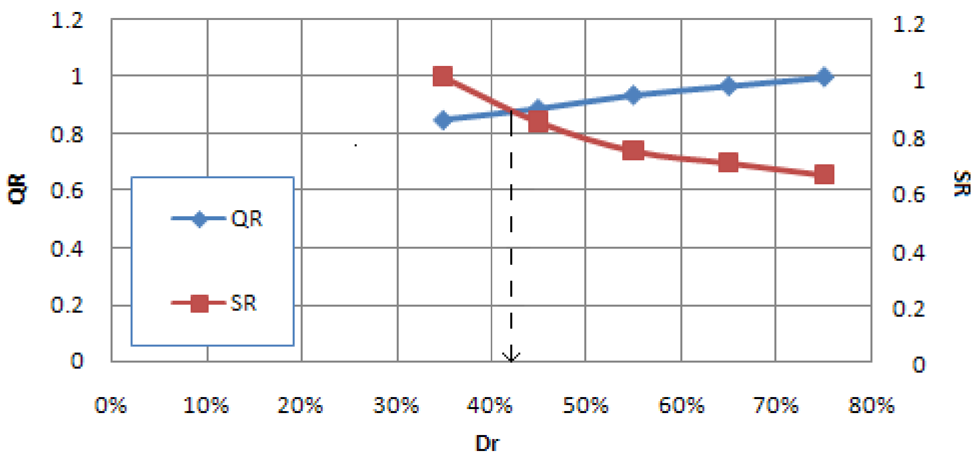

Fig. 6. The optimum condition for QR and SR

9. Conclusions

Since, we used large scale model in the present study, we were faced several limitations as follows: First, the tests were conducted on only one soil type at different Dr and on only one type of geotextile reinforcement. Second, the vertical spacing between the reinforcement layers was constant. Third, since dry sand was used in this study, thus the compaction was very difficult, therefore, maximum Dr selected for these tests was Dr=75%.

The effects of Dr of sand reinforced backfills with geotextile are as follow:

1. The rate of variation in QR increased when the Dr increases.
2- The rate of variation in SR decreased when the Dr increases.

10. Acknowledgment

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